# Tetracyclines, Oral
# Therapeutic Class Review (TCR)

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## FDA-APPROVED INDICATIONS[1]

Tetracycline antibiotics, with the exception of doxycycline hyclate 20 mg, doxycycline monohydrate delayed-release 40 mg (Oracea®), omadacycline (Nuzyra®), sarecycline (Seysara®), doxycycline hyclate 100mg tablets (Lymepak™), and minocycline extended-release (Solodyn®, Minolira®, Ximino®), are indicated for the treatment of the following infections:

- Ophthalmic infections
  - Trachoma caused by *Chlamydia trachomatis*, although the infectious agent is not always eliminated as judged by immunofluorescence.
  - Inclusion conjunctivitis caused by *Chlamydia trachomatis*
- Rickettsial infections
  - Rocky Mountain spotted fever, typhus fever and the typhus group, Q fever, rickettsialpox, and tick fevers
- Respiratory tract infections
  - Respiratory tract infections caused by *Mycoplasma pneumoniae*
  - Psittacosis (ornithosis) caused by *Chlamydia psittaci*
  - When bacteriologic testing indicates appropriate susceptibility to the drug
    - Respiratory tract infections caused by *Haemophilus influenzae*
    - Respiratory tract caused by *Klebsiella* species
    - Upper respiratory infections caused by *Streptococcus pneumoniae*
- Sexually transmitted infections
  - Uncomplicated urethral, endocervical, or rectal infections in adults caused by *Chlamydia trachomatis*
  - Nongonococcal urethritis caused by *Ureaplasma urealyticum*
  - Lymphogranuloma venereum caused by *Chlamydia trachomatis*
  - Granuloma inguinale caused by *Calymmatobacterium granulomatis*
  - Chancroid caused by *H. ducreyi*
- Specific bacterial infections
  - Plague due to *Yersinia pestis*
  - Tularemia due to *Francisella tularensis*
  - Cholera caused by *Vibrio cholerae*
  - Campylobacter fetus infections caused by *Campylobacter fetus*
  - Brucellosis due to *Brucella* species (in conjunction with streptomycin)
  - Bartonellosis due to *Bartonella bacilliformis*
  - Relapsing fever due to *Borrelia recurrentis*

- Because many strains of the following groups of microorganisms have shown resistance to tetracycline antibiotics, these agents are indicated for treatment of infections caused by the following gram-negative microorganisms, when bacteriologic testing indicates appropriate susceptibility to the drug:
  - ❒ *Escherichia coli*
  - ❒ *Enterobacter aerogenes*
  - ❒ *Shigella* species
  - ❒ *Acinetobacter* species
  - ❒ Urinary tract infections caused by *Klebsiella* species
- Anthrax due to *Bacillus anthracis*, including inhalational anthrax (postexposure), to reduce the incidence or progression of disease following exposure to aerosolized *Bacillus anthracis*
- Alternative treatment when penicillin is contraindicated
  - ❒ Uncomplicated gonorrhea caused by *Neisseria gonorrhoeae* (with the exception of Doryx®)
  - ❒ Syphilis caused by *Treponema pallidum*
  - ❒ Yaws caused by *Treponema pertenue*
  - ❒ Listeriosis due to *Listeria monocytogenes* (with the exception of Doryx)
  - ❒ Vincent's infection caused by *Fusobacterium fusiforme*
  - ❒ Actinomycosis caused by *Actinomyces israelii*
  - ❒ Infections caused by *Clostridium* species
- Acute intestinal amebiasis, as adjunct therapy to amebicides
- Severe acne, as adjunctive therapy

### *FDA-Approved Indications (continued)*

| Drug | Manufacturer | Additional Indication(s) |
|---|---|---|
| demeclocycline[2] | generic | ▪ Skin and skin structure infections caused by *Staphylococcus aureus* (Note: not the drug of choice); see package insert for full indications |
| doxycycline* (Vibramycin®)[3,4,5] | generic, Pfizer | ▪ Vibramycin only: Prophylaxis of malaria due to *Plasmodium falciparum* in short-term travelers (< 4 months) to areas with chloroquine and/or pyrimethamine-sulfadoxine resistant strains |
| doxycycline hyclate (Acticlate, Lymepak)[6,7] | Aqua, Lifsa | ▪ Prophylaxis of malaria due to *Plasmodium falciparum* in short-term travelers (< 4 months) to areas with chloroquine and/or pyrimethamine-sulfadoxine resistant strains (Acticlate only)<br>▪ Treatment of early Lyme disease due to *Borrelia burgdorferi* in those aged 8 years and older weighing ≥ 45 kg or more (Lymepak only) |
| doxycycline hyclate† (20 mg tablets)[8] | generic | ▪ Adjunct to scaling and root planing to promote attachment level gain and to reduce pocket depth in patients with adult periodontitis |
| doxycycline hyclate delayed-release tablets (Doryx, Doryx MPC®, Morgidox®, Targadox®)[9,10,11,12] | generic, Mayne, Medimetriks, Journey | ▪ Prophylaxis of malaria due to *Plasmodium falciparum* in short-term travelers (< 4 months) to areas with chloroquine and/or pyrimethamine-sulfadoxine resistant strains |
| doxycycline monohydrate capsules (Monodox®)[13] | generic, Aqua | ▪ Indications as listed above<br>▪ Skin and skin structure infections caused by *S. aureus* (Note: not the drug of choice) |
| doxycycline monohydrate delayed-release (DR) (Oracea)[14] | generic†, Galderma | ▪ Treatment of only inflammatory lesions (papules and pustules) of rosacea in adult patients; efficacy beyond 16 weeks and safety beyond 9 months have not been established. |
| minocycline (Minocin®)[15] | generic, Valeant | ▪ Treatment of meningococcal infection<br>▪ Treatment of symptomatic carriers of *Neisseria meningitidis* to eliminate the meningococci from the nasopharynx<br>▪ Skin and skin structure infections caused by *S. aureus* (Note: not the drug of choice)<br>▪ Although no controlled clinical efficacy studies have been conducted, limited clinical data show that oral minocycline has been used successfully in the treatment of infections caused by *Mycobacterium marinum* |
| minocycline extended-release (ER) (Solodyn, Minolira, Ximino†)[16,17,18] | generic, Valeant, Promium, Journey | ▪ Treatment of only inflammatory lesions of non-nodular moderate to severe acne vulgaris in patients ≥ 12 years of age. |
| omadacycline (Nuzyra)[19] | Paratek | ▪ Treatment of adult patients with community-acquired bacterial pneumonia (CABP)<br>▪ Treatment of adult patients with acute bacterial skin and skin structure infections (ABSSSI) caused by susceptible microorganisms |
| sarecycline (Seysara)[20] | Almirall | ▪ Treatment of inflammatory lesions of non-nodular moderate to severe acne vulgaris in patients ≥ 9 years of age‡. |

* Vibramycin (doxycycline) is available in calcium, hyclate, and monohydrate salts.

† Authorized generic available.

‡ Limitation of use: has not been evaluated and should only be used as indicated (acne vulgaris) to reduce the development of drug-resistant bacteria.

***FDA-Approved Indications (continued)***

| Drug | Manufacturer | Additional Indication(s) |
|---|---|---|
| tetracycline[21] | generic | ▪ Respiratory tract infections due to *Streptococcus pyogenes*<br>▪ Lower respiratory tract infections due to *Streptococcus pyogenes or S. pneumoniae*<br>▪ Skin and skin structure infections caused by *S. pyogenes* or *S. aureus* (Note: not the drug of choice for infections caused by *S. aureus*)<br>▪ Infections caused by *N. gonorrhoeae* |

## OVERVIEW

Tetracyclines have been around since the introduction of chlortetracycline in 1948. Tetracycline antibiotics have similar antimicrobial spectra and safety profiles and are used for the treatment of a variety of infectious diseases. However, with increasing bacterial resistance to the tetracyclines and with the development of newer antimicrobial agents, the number of uses for these drugs is declining. In patients unable to take penicillin, tetracyclines are an alternative in the treatment of Lyme disease, syphilis, and brucellosis.

The 2021 Centers for Disease Control and Prevention (CDC) sexually transmitted diseases (STD) guidelines recommend doxycycline for the treatment of nongonococcal urethritis.[22] Doxycycline is considered an alternative agent for the treatment of granuloma inguinale (azithromycin is now the preferred agent); however, it is still the preferred drug to treat lymphogranuloma venereum, cervicitis, and infections due to chlamydia. In the treatment of mild to moderate pelvic inflammatory disease, outpatient therapy with intramuscular ceftriaxone plus oral doxycycline, with or without oral metronidazole, is recommended. Intramuscular cefoxitin plus oral probenecid plus doxycycline, with or without metronidazole, may also be considered. Doxycycline is part of the treatment regimen for acute epididymitis and proctitis and STD rectal infections when gonococcal and/or chlamydia infections are presumed. Doxycycline and tetracycline are alternatives for the treatment in syphilis when a patient has a severe penicillin allergy. Doxycycline is preferred over tetracycline due to the potential for greater gastrointestinal intolerance associated with tetracycline.

The joint guidelines from the American Thoracic Society (ATS) and Infectious Diseases Society of America (IDSA) for the treatment of community-acquired pneumonia (CAP) published in 2019 recommend either amoxicillin (strong recommendation) or doxycycline (conditional recommendation) or a macrolide (e.g., erythromycin, clarithromycin, azithromycin – conditional recommendation) for adult patients who are otherwise healthy without risk factors for multidrug resistant *S. pneumoniae*.[23] For adult outpatients with comorbidities, including chronic heart, lung, renal, and hepatic disorders; diabetes; alcoholism; malignancies; asplenia; immunosuppression; or use of any antibiotic within the last 3 months or other risk factors for multi-drug resistant *S. pneumoniae*; first-line therapy may include a respiratory fluoroquinolone as monotherapy (moxifloxacin, gemifloxacin, or levofloxacin – strong recommendation), or in combination with amoxicillin/clavulanic acid or a cephalosporin plus a macrolide (strong recommendation), or doxycycline (conditional recommendation). Omadacycline is indicated for use to treat adults with CABP. Omadacycline has demonstrated noninferiority to moxifloxacin, but it has not yet been addressed in treatment guidelines.

The CDC recommends ciprofloxacin, levofloxacin, or doxycycline for the initial treatment of inhalational anthrax. Since there are no safety data available for levofloxacin use beyond 30 days, oral ciprofloxacin

and doxycycline are recommended over levofloxacin.[24,25] Other agents suggested for use in the event the first-line agents are unavailable or not tolerated include moxifloxacin and clindamycin. Amoxicillin and penicillin VK are options if the isolate is penicillin-susceptible. Cephalosporins and trimethoprim/ sulfamethoxazole should not be used for therapy. Prophylaxis for inhalational anthrax exposure should include 60 days of antimicrobial therapy started as soon after the exposure as possible along with a 3-dose series of Anthrax Vaccine Adsorbed. The American Academy of Pediatrics (AAP) 2014 guideline for treating pediatric patients exposed to aerosolized spores recommends treatment for an initial 10 days with either doxycycline or ciprofloxacin, followed by another 50 days of therapy.[26] The potential benefits of both agents outweigh their potential risks (doxycycline: tooth discoloration; ciprofloxacin: cartilage injury).

In the treatment of acne vulgaris, the 2016 guidelines from the American Academy of Dermatology state that systemic antibiotics including tetracyclines (recommendation grade A – consistent and good quality patient-oriented evidence; grade 1 - good quality patient-oriented evidence) are a standard of care in the management of moderate and severe acne and treatment-resistant forms of inflammatory acne.[27] According to the guidelines, doxycycline and minocycline are more effective than tetracycline, but neither is preferred over the other. For eradication of *Propionibacterium acnes*, there was some evidence previously indicating that minocycline is superior to doxycycline. However, a Cochrane review of the literature found that not to be the case; it is effective, but not superior. Other systemic antibiotics mentioned for the management of moderate to severe acne include erythromycin, trimethoprim, and trimethoprim/sulfamethoxazole when the use of tetracyclines is contraindicated. Sarecycline, approved in 2018, has not yet been addressed in the guidelines; it is approved for moderate to severe acne vulgaris in those aged 9 years and older.

ABSSSIs include bacterial infections of skin, subcutaneous tissue, fascia, and muscles and can have various diagnoses based on clinical presentation, location, and presence of purulence.[28] Antibiotic treatment is based on presenting symptoms (mild to severe), with debridement or drainage if clinically appropriate. ABSSSIs are often caused by beta-hemolytic streptococcus, *S. aureus*, or *S. pyogenes*, but they can also be caused by multiple organisms (e.g., diabetic wound infections). In addition, the potential cause of the infection, if known (e.g., human or animal bite), can also guide empiric therapy based on common pathogens. According to the IDSA's 2014 practice guidelines, mild infections may be empirically treated with an oral penicillin, a first- or second-generation cephalosporin, or clindamycin.[29] For simple abscesses, incision and drainage alone may be adequate. Moderate non-purulent infections can be treated with IV antibiotics, with an added role for broader spectrum agents (e.g., doxycycline) and others that can cover methicillin-resistant *S. aureus* (MRSA) (e.g., sulfamethoxazole/trimethoprim). Patients with a severe infection or whose infection is progressing despite empirical antibiotic therapy should be treated more aggressively, and the treatment strategy should be based upon results of appropriate Gram stain, culture, and susceptibility analysis, if available. *S. aureus* and *S. pyogenes* frequently develop resistance to methicillin and erythromycin, respectively. Empiric choices of antimicrobials must include agents with activity against resistant strains. Most community-acquired MRSA strains remain susceptible to sulfamethoxazole/trimethoprim and tetracyclines, although recent data on the use of tetracyclines are more limited. Additional MRSA treatment options include clindamycin and linezolid, as well as IV daptomycin, ceftaroline, and vancomycin. Duration of treatment is based on clinical response and location of infection. For instance, generally 5 days is recommended for cellulitis, although an extended treatment may be required if the

infection has not improved within 5 days. As a newly approved agent, omadacycline has yet to be addressed in treatment guidelines for ABSSSI.

## PHARMACOLOGY[30,31]

The tetracyclines are bacteriostatic. They exert their antimicrobial effect by reversibly binding to the 30S subunit of the bacterial ribosome, preventing the binding of tRNA to the mRNA-ribosome complex, thereby inhibiting protein synthesis and, thus, cell growth. Tetracyclines are active against a wide range of gram-positive and gram-negative organisms and have similar antimicrobial spectra; cross-resistance is common.

Doxycycline and minocycline, both long-acting, are more lipid-soluble than other tetracyclines and have minimal renal clearance, making them drugs of choice in patients with compromised renal function.

Doxycycline is available in 2 oral solid dosage formulations – monohydrate and hyclate. Both forms are equally effective, but 1 form may not be substituted for the other. The bioavailability of doxycycline monohydrate may be lower at high pH which could be clinically significant for patients on long-term acid suppression therapy or patients with gastrectomy or gastric bypass surgery. Monohydrate dosage forms may dissolve slower in the stomach which potentially could reduce gastrointestinal adverse effects. Doxycycline hyclate dosage forms may be taken with food if stomach irritation occurs.

The action of tetracyclines in the treatment of acne vulgaris is believed to be due in part to their antibacterial actions. Skin bacteria produce lipase that breaks down triglycerides present in sebum into free fatty acids, which are comedogenic and may be the cause of the inflammatory lesions of acne. Antibacterial and anti-inflammatory actions are 2 possible mechanisms of tetracyclines.

Demeclocycline is used infrequently for the treatment of infections but has utility in the treatment of syndrome of inappropriate antidiuretic hormone (SIADH). Demeclocycline antagonizes the actions of vasopressin at the collecting duct in the nephron; it produces diuresis by inhibiting ADH-induced water reabsorption in the distal portion of the convoluted tubules. Effects are seen within 5 days and can be reversed within 2 to 6 days following the end of therapy. It has a lower risk of toxicity than lithium for this condition, and is, thereby, favored by clinicians.

In the treatment of periodontitis, it is thought that doxycycline works by inhibiting collagenase which breaks down connective tissue and leads to the separation of the gum from the tooth. The exact mechanism, however, is not known.

Omadacycline, an aminomethylcycline within the tetracycline class, is active *in vitro* against gram-positive bacteria with tetracycline resistance active efflux pumps (*tetK* and *tetL*) and ribosomal protection proteins (*tetM*).

### Spectrum of Activity

The tetracyclines are active against gram-positive and gram-negative bacteria. Doxycycline is typically active against *Bacillus anthracis, Listeria monocytogenes*, and *S. aureus,* although tetracyclines are not the drug of choice in the treatment of any type of staphylococcal infection. The tetracyclines are unreliable against streptococcal infections, as resistance rates have been reported to be 50%. Use of any tetracycline for a streptococcal infection should be guided by culture and sensitivity data. Doxycycline is typically effective against the following gram-negative organisms: *Bartonella*

*bacilliformis, Brucella species, Calymmatobacterium granulomatis, Campylobacter fetus, Francisella tularensis, Haemophilus ducreyi, Haemophilus influenzae, Neisseria gonorrhoeae, Vibrio cholerae,* and *Yersinia pestis*. Culture and sensitivity data for other gram-negative organisms should be consulted. Most *Rickettsia* bacteria are susceptible to the tetracyclines. Tetracycline is commonly used in combination with bismuth salts and metronidazole plus acid suppression therapy in the treatment of *H. pylori*.

Per product labeling, omadacycline-susceptible organisms of CABP include *S. pneumoniae*, *S. aureus* (methicillin-susceptible isolates; MSSA), *H. influenzae*, *H. parainfluenzae*, *K. pneumoniae*, *Legionella pneumophila*, *M. pneumoniae*, and *Chlamydophila pneumoniae*.

Omadacycline-susceptible organisms of ABSSSI include *S. aureus* (methicillin-susceptible and -resistant isolates), *Staphylococcus lugdunensis*, *S. pyogenes*, *Streptococcus anginosus* group (includes *S. anginosus*, *S. intermedius*, and *S. constellatus*), *Enterococcus faecalis*, *Enterobacter cloacae*, and *K. pneumoniae*.

Sarecycline displays *in vitro* activity against most *Propionibacterium acnes* isolates; however, the clinical significance is unknown.

## PHARMACOKINETICS[32,33,34,35,36,37,38,39,40,41]

| Drug | Half-life (hrs) | Elimination (%) |
|---|---|---|
| demeclocycline | 10-17 | Urine: 42<br>Feces: 42 |
| doxycycline (Vibramycin) | 18-22 | Doxycycline is excreted in the urine and feces as unchanged drug |
| doxycycline monohydrate | 16.33 | |
| doxycycline hyclate (Acticlate, Acticlate CAP, Targadox, Vibramycin, Lymepak) | 18-22 | |
| doxycycline hyclate DR (Doryx, Doryx MPC*) | 18-22 | |
| doxycycline monohydrate (Monodox) | n/a | |
| doxycycline monohydrate delayed release (DR) (Oracea)† | 23.2 | |
| minocycline | 11-22 | Partially metabolized<br>Renal: 4-19<br>Feces: reported |
| minocycline ER (Minolira)‡ | 15.6-17.1 | |
| minocycline (ER) (Solodyn, Ximino)§ | 11-18 | |
| omadacycline (Nuzyra) | 16 | Urine: ≈ 14<br>Feces: majority elimination |
| sarecycline (Seysara) | 21-22 | Urine: 44<br>Feces: 42.6 |
| tetracycline | 6-12 | Urine: 60<br>Feces: reported |

n/a = not available

* Doryx MPC is a new technology that insulates the release of doxycycline hyclate in the acidic environment of the stomach. In pharmacokinetic studies, Doryx MPC was found to be bioequivalent to Doryx 100 mg; it is not substitutable on a mg per mg basis.

† Capsules contain 2 types of beads for biphasic release: immediate release and delayed release in a 3:1 ratio, respectively.

‡ Tablets contain 2 types of beads for biphasic release: immediate release and delayed release in a 1:3 ratio, respectively.

§ Minocycline extended-release (Solodyn, Ximino) is not bioequivalent to immediate-release minocycline products.

## CONTRAINDICATIONS/WARNINGS[42,43,44,45,46,47,48,49,50,51,52,53,54]

These agents are contraindicated in any persons with hypersensitivity to the active ingredient or to any of the tetracyclines.

The use of drugs of the tetracycline class during tooth development (last half of pregnancy, infancy, and childhood to the age of 8 years) may cause permanent discoloration of the teeth (yellow-gray-brown). This adverse effect is more common during long-term use of the drugs but has been observed following repeated short-term courses. Enamel hypoplasia has also been reported. Tetracycline drugs, therefore, should only be used in those ≤ 8 years of age only when the potential benefits are expected to outweigh the risks in severe or life-threatening conditions, particularly when there are no alternative therapies.

All tetracyclines form a stable calcium complex in any bone-forming tissue. A decrease in the fibula growth rate has been observed in premature infants given oral tetracycline in doses of 25 mg/kg every 6 hours. This reaction was shown to be reversible when the drug was discontinued.

*Clostridium difficile*-associated diarrhea (CDAD) has been reported with use of nearly all antibacterial agents, including the tetracycline class, and may range in severity from mild diarrhea to fatal colitis. Treatment with antibacterial agents alters the normal flora of the colon, leading to overgrowth of *C. difficile*. *C. difficile* produces toxins A and B which contribute to the development of CDAD. Hypertoxin-producing strains of *C. difficile* cause increased morbidity and mortality, as these infections can be refractory to antimicrobial therapy and may require colectomy. CDAD must be considered in all patients who present with diarrhea following antibiotic use. A detailed medical history is necessary since CDAD has been reported to occur > 2 months after the administration of antibacterial agents. If CDAD is suspected or confirmed, ongoing antibiotic use not directed against *C. difficile* may need to be discontinued. Appropriate fluid and electrolyte management, protein supplementation, antibiotic treatment of *C. difficile*, and surgical evaluation should be instituted as clinically indicated. If pseudomembranous colitis occurs during treatment with one of these agents, discontinue the drug.

As with other antibiotic preparations, use of tetracyclines may result in overgrowth of nonsusceptible organisms, including fungi. If superinfection occurs, the antibiotic should be discontinued, and appropriate therapy should be instituted. Doxycycline hyclate 20 mg should be used with caution in patients with a history or predisposition to oral candidiasis. Doxycycline hyclate 100 mg tablets when used as indicated for Lyme disease, may cause Jarisch-Herxheimer reaction after initiation of therapy. Monitor for severe reaction; antipyretics may reduce the severity and duration of the reaction.[55]

The anti-anabolic action of the tetracyclines may cause an increase in blood urea nitrogen (BUN). Studies to date indicate that this does not occur with the use of doxycycline in patients with impaired renal function.

Photosensitivity manifested by an exaggerated sunburn reaction has been observed in some individuals taking tetracyclines. Patients apt to be exposed to direct sunlight or ultraviolet light should be advised that this reaction can occur with tetracycline drugs, and treatment should be discontinued at the first evidence of skin erythema.

Tetracycline agents are known to cause hyperpigmentation. Tetracycline therapy may induce hyperpigmentation in various organs, including nails, bone, skin, eyes, thyroid, visceral tissue, oral cavity (teeth, mucosa, and alveolar bone), sclera, and heart valves. Skin and oral pigmentation has

been reported to occur independently of time or amount of drug administration, whereas other pigmentation has been reported to occur upon prolonged administration. Skin pigmentation includes diffuse pigmentation, as well as over sites of scars or injury.

Pseudotumor cerebri (benign intracranial hypertension) in adults has been associated with the use of tetracyclines. The usual clinical manifestations are headache and blurred vision. Bulging fontanels have been associated with the use of tetracyclines in infants. While both conditions and related symptoms usually resolve soon after discontinuation of the tetracycline, the possibility for permanent sequelae exists; therefore, it is advised that patients be monitored until stabilization occurs.

Administration of demeclocycline has resulted in appearance of the diabetes insipidus syndrome (polyuria, polydipsia, and weakness) in some patients on long-term therapy. The syndrome has been shown to be nephrogenic, dose-dependent, and reversible on discontinuance of therapy.

Central nervous system (CNS) adverse effects, including dizziness, vertigo, and lightheadedness, may occur with agents in this class. Patients experiencing CNS adverse effects should be cautioned about driving vehicles and using hazardous machinery while on therapy. The symptoms may disappear during therapy and usually rapidly disappear upon discontinuation.

Doxycycline syrup (Vibramycin) contains sodium metabisulfite, a sulfite that may cause allergic-type reactions, including anaphylactic symptoms and life-threatening or less severe asthmatic episodes in certain susceptible people. The overall prevalence of sulfite sensitivity in the general population is unknown and probably low. Sulfite sensitivity is seen more frequently in asthmatic than in non-asthmatic people.

Thyroid gland changes have also been reported with use of tetracyclines, including doxycycline hyclate DR tablets (Doryx/MPC), when given over long periods of time. Discoloration of the thyroid has been reported, but no change in thyroid function has been observed.

The plasma concentrations of doxycycline (Oracea) achieved during administration are less than the concentration required to treat bacterial diseases. *In vivo* microbiological studies utilizing a similar drug exposure for up to 18 months demonstrated no detectable long-term effects on bacterial flora of the oral cavity, skin, intestinal tract, and vagina. The Oracea dosage form of doxycycline should not be used for treating bacterial infections, providing antibacterial prophylaxis, or reducing the numbers or eliminating microorganisms associated with any bacterial disease.

Hepatotoxicity has been reported with minocycline; therefore, if liver injury is suspected, discontinue minocycline (Solodyn, Minolira, Ximino). Minocycline should be used with caution in patients with hepatic dysfunction and in conjunction with other hepatotoxic drugs. Tetracyclines have been associated with the development of autoimmune syndromes. The long-term use of minocycline in the treatment of acne has been associated with drug-induced lupus-like syndrome, autoimmune hepatitis, and vasculitis.

Drug Rash with Eosinophilia and Systemic Symptoms (DRESS), including fatal cases, has been reported with minocycline use. If this syndrome is recognized, the drug should be discontinued immediately.

Omadacycline carries a warning regarding mortality imbalance. Compared to patients treated with moxifloxacin for CABP, a higher rate of death was observed in patients treated with omadacycline (2% compared to 1% with moxifloxacin) in a key clinical trial; however, the cause of the difference in mortality has not been established.

## DRUG INTERACTIONS[56,57,58,59,60,61,62,63,64,65,66,67,68]

Tetracyclines, as a class, have been shown to increase levels of anticoagulants. International normalized ratio (INR) should be monitored for patients on warfarin therapy. Patients who are on anticoagulant therapy may require downward adjustment of their anticoagulant dosage when on concurrent tetracycline therapy.

Concurrent use of a tetracycline may render oral contraceptives less effective. Female patients are advised to use a second form of contraceptive during treatment with tetracycline.

Since bacteriostatic drugs may interfere with the bactericidal action of penicillin, it is advisable to avoid giving tetracyclines in conjunction with penicillin. Absorption of tetracyclines is impaired by antacids containing aluminum, calcium, or magnesium, and iron-containing preparations. Barbiturates, carbamazepine, and phenytoin decrease the half-life of doxycycline. The concurrent use of tetracycline and methoxyflurane has been reported to result in fatal renal toxicity. There is an increased risk of ergotism when ergot alkaloids or their derivatives are given with tetracyclines.

Reports of pseudotumor cerebri (benign intracranial hypertension) have been associated with the concomitant use of isotretinoin and tetracyclines. Since both oral retinoids, including isotretinoin and acitretin, and the tetracyclines, primarily minocycline, can cause increased intracranial pressure, their concurrent use should be avoided.

Divalent and trivalent cations bind with and inhibit oral absorption of tetracyclines. Doxycycline appears to have a lower affinity for calcium and a higher affinity for iron than the other agents. Because of the binding, it is advisable to take oral tetracyclines on an empty stomach.

## ADVERSE EFFECTS[69,70,71,72,73,74,75,76,77,78,79,80,81,82]

The following adverse effects have been reported in patients receiving tetracyclines:

**Gastrointestinal:** Anorexia, nausea, vomiting, diarrhea, glossitis, dysphagia, enterocolitis, pancreatitis, inflammatory lesions (with monilial overgrowth) in the anogenital region, increases in liver enzymes, and hepatic toxicity (including hepatitis and liver failure)

Due to virtually complete absorption of oral doxycycline and oral minocycline, adverse effects of the lower bowel, particularly diarrhea, have been infrequent. With minocycline, stomatitis, dysphagia, and enamel hypoplasia have been reported.

Instances of esophageal ulcerations have been reported in patients receiving oral tetracyclines. Most of the patients reported taking the medication immediately before lying down.

With minocycline, additional hepatic adverse effects have included hyperbilirubinemia, hepatic cholestasis, and jaundice. Hepatitis, including autoimmune hepatitis, and liver failure have been reported with minocycline use. Lupus-like symptoms have also been reported with minocycline use.

**Skin:** Maculopapular and erythematous rashes, erythema multiforme. Jarisch-Herxheimer reactions and skin hyperpigmentation have been associated with doxycycline (Vibramycin, Lymepak) use. These have been added to the package insert in the adverse events section.

Exfoliative dermatitis has been reported but is uncommon. Fixed drug eruptions and Stevens-Johnson syndrome have been reported rarely. Lesions occurring on the glans penis have caused balanitis. Pigmentation of the skin and mucous membranes has also been reported. Photosensitivity can occur.

When compared with tetracycline, demeclocycline is associated with a higher incidence of phototoxicity. With minocycline, alopecia, erythema nodosum, hyperpigmentation of nails, pruritus, toxic epidermal necrolysis, and vasculitis have been reported.

With omadacycline, infusion site reaction with the IV formulation was one of the more common reported adverse effects.

**Renal Toxicity:** Acute renal failure

Elevation in BUN have been reported and is apparently dose-related. Nephrogenic diabetes insipidus has been reported.

**Hypersensitivity Reactions:** Urticaria, angioneurotic edema, polyarthralgia, anaphylaxis, anaphylactoid purpura, pericarditis, exacerbation of systemic lupus erythematosus, lupus-like syndrome, pulmonary infiltrates with eosinophilia

**Hematologic:** Hemolytic anemia, thrombocytopenia, neutropenia, and eosinophilia have been reported.

With minocycline, agranulocytosis and pancytopenia have been reported.

**CNS:** Pseudotumor cerebri (benign intracranial hypertension) in adults; this condition usually resolves after discontinuation, but there is the possibility of permanent vision loss. If visual disturbances occur during treatment, see an ophthalmologist. Intracranial pressure can remain elevated for weeks after discontinuing drug; monitor patients until the pressure stabilizes, monitor dizziness, headache, tinnitus, visual disturbances, and myasthenic syndrome.

With minocycline, convulsions, headache, sedation, vertigo, hypesthesia, tinnitus, decreased hearing, and paresthesia have also been reported. Insomnia was reported with omadacycline use.

**Musculoskeletal:** With minocycline, arthralgia, arthritis, bone discoloration, myalgia, joint stiffness, and joint swelling have been reported.

**Other:** When given over prolonged periods, tetracyclines have been reported to produce brown-black microscopic discoloration of thyroid glands. No abnormalities of thyroid function studies are known to occur. Very rare cases of abnormal thyroid function have been reported.

Tooth discoloration has occurred in pediatric patients < 8 years of age and has been reported rarely in adults.

Sarecycline use resulted in reports of vulvovaginal mycotic infections and candidiasis along with nausea. No other adverse effects were reported with its use.

## SPECIAL POPULATIONS[83,84,85,86,87,88,89,90,91,92,93,94,95]

### Pediatrics

Use of tetracycline products in children < 8 years of age is not recommended due to the potential for tooth discoloration; an exception to this is the use of doxycycline for life-threatening conditions (e.g., anthrax, Rocky Mountain spotted fever). Safety and effectiveness of minocycline ER (Solodyn, Minolira, Ximino) in children < 12 years of age have not been established. Safety and effectiveness of sarecycline (Seysara) in children < 9 years of age have not been established. Safety and effectiveness of omadacycline (Nuzyra) in patients < 18 years have not been established.

## Pregnancy

All agents in this class are Pregnancy Category D. Some labels have been updated to comply with the Pregnancy and Lactation Label Rule (PLLR), informing that there are no adequate and well-controlled trials in pregnant women to inform of risk of adverse effects on the fetus; however, as described above in the warnings, use during pregnancy may cause permanent discoloration of teeth and reversible inhibition of bone growth when administered during pregnancy. In addition, post-marketing cases of select tetracycline class medication use in pregnant women have reported congenital anomalies (e.g., limb reductions). If patients become pregnant while taking a tetracycline, the patient should be advised of the risk and treatment should be discontinued.

## Renal Impairment

If renal impairment is present, minocycline (Solodyn, Minolira, Ximino) doses may need to be adjusted to avoid excessive systemic accumulation of the drug and possible liver toxicity.

The effects of severe hepatic impairment (Child-Pugh Class C) and end-stage renal disease (ESRD) on sarecycline pharmacokinetics have not been established.

No dose adjustment of omadacycline is required in the presence of either renal or hepatic impairment.

## DOSAGES[96,97,98,99,100,101,102,103,104,105,106,107,108,109,110,111,112,113,114,115,116,117,118]

| Drug | Usual Dosing | Availability |
|---|---|---|
| demeclocycline | **Adults:** 150 mg 4 times daily or 300 mg twice daily<br>Gonorrhea patients sensitive to penicillin: initial oral dose of 600 mg followed by 300 mg every 12 hours for 4 days to a total of 3 g<br>**Pediatrics > 8 years**: 7 to 13 mg/kg/day depending on severity of disease, divided into 2 to 4 doses, not to exceed dosage of 600 mg daily | 150 mg, 300 mg tablets |
| doxycycline calcium, hyclate, or monohydrate (Acticlate, Doryx, Doryx MPC, Morgidox, Targadox, Vibramycin, Lymepak) | **Adults:** 100 mg twice daily for most infections; duration of therapy is typically 7 to 10 days, but duration may depend on severity of infection<br>Inhalational anthrax: 100 mg twice daily for 60 days<br>Prophylaxis of malaria: 100 mg daily beginning 1 to 2 days before travel and continuing for 4 weeks after leaving malarious area<br>Syphilis: 300 mg a day in divided doses for ≥ 10 days<br>**Pediatrics > 8 years and < 45 kg**: 2.2 mg/kg give twice daily on Day 1, then 2.2 mg/kg daily; for more severe infections, up to 4.4 mg/kg may be used (if > 45 kg, use adult dosing)<br>Prophylaxis for malaria: 2 mg/kg once daily (not to exceed 100 mg)<br>*Doryx MPC only*<br>Adults: 240 mg on the first day of treatment in 120 mg doses 12 hours apart, then 120 mg daily<br>Pediatrics: < 45 kg: 2.6 mg/kg every 12 hours for severe, life-threatening infections; > 8 years and < 45 kg: 5.3 mg/kg divided into 2 doses on day 1, then 2.6 mg/kg daily<br>The contents of Doryx tablets (doxycycline delayed-release pellets) may be sprinkled on a spoonful of applesauce; the delayed-release pellets must not be crushed, chewed, or damaged when breaking up the tablet<br>*Lymepak only*<br>Adults and pediatrics > 8 years and > 45 kg for early Lyme disease: 100 mg tablet every 12 hours for 21 days | **doxycycline *calcium*:**<br>50 mg/5 mL syrup (Vibramycin)<br>**doxycycline *hyclate*:**<br>50 mg and 100 mg capsules (Morgidox* 50 mg and 100 mg only; Vibramycin 100 mg only)<br>50 mg, 75 mg, 100 mg, 150 mg tablets (Targadox* 50 mg only; Lymepak 100 mg)<br>**doxycycline *hyclate DR*:**<br>50 mg, 75 mg, 80 mg, 100 mg, 120 mg, 150 mg, 200 mg DR tablet (Doryx DR 50 mg, 80 mg, 200 mg only; Doryx MPC 120 mg only; 75 mg, 100 mg, and 150 mg generic only)<br>**doxycycline *monohydrate*:**<br>50 mg, 75 mg, 100 mg, 150 mg capsules (Mondoxyne NL * 75 mg, 100 mg only)<br>50 mg, 75 mg, 100 mg, 150 mg tablets (Avidoxy™* 100 mg; 50 mg, and 150 mg generic only)<br>25 mg/5 mL powder for oral suspension (Vibramycin) |
| doxycycline hyclate (Acticlate) | **Adults:** 200 mg on first day (given as 100 mg every 12 hours) followed by a maintenance dose of 100 mg daily<br>**Pediatrics (> 8 years):** ≤ 45 kg 4.4 mg/kg of body weight divided into 2 doses the first day, followed by 2.2 mg/kg given as either a single daily dose, or divided into 2 doses on subsequent days (for those weighing > 45 kg, use the adult dosing schedule) | 75 mg and 150 mg functionally scored tablets |

* Approved under an abbreviated new drug application and considered a generic product.

***Dosages (continued)***

| Drug | Usual Dosing | Availability |
|---|---|---|
| doxycycline hyclate | Periodontitis: 20 mg every 12 hours as an adjunct following scaling and root planing may be administered for up to 9 months | 20 mg tablet |
| doxycycline monohydrate capsules (Monodox) | Skin and skin structure infections caused by *S. aureus* (Note: not the drug of choice)<br>**Adults:** 200 mg on first day (given as 100 mg every 12 hours or 50 mg every 6 hours) followed by a maintenance dose of 100 mg daily (single dose or 50 mg every 12 hours)<br>**Pediatrics (> 8 years):** ≤ 45 kg 4.4 mg/kg of body weight divided into 2 doses the first day, followed by 2.2 mg/kg given as either a single daily dose, or divided into 2 doses on subsequent days (for those weighing > 45 kg, use the adult dosing schedule)<br>For all pediatric patients weighing < 45 kg with severe or life-threatening infections (e.g., anthrax, Rocky Mountain spotted fever), the recommended dosage is 2.2 mg/kg of body weight administered every 12 hours; children weighing ≥ 45 kg should receive the adult dose | 50 mg, 75 mg, 100 mg capsules |
| doxycycline monohydrate DR (Oracea) | **Adults:** 1 capsule daily in the morning on an empty stomach, preferably at least 1 hour prior to or 2 hours after meals; Oracea differs from doxycycline used to treat infections; Exceeding recommended dosage can result in higher incidence of adverse effects | 40 mg capsules with 30 mg immediate-release and 10 mg DR beads |
| minocycline (Minocin) | **Adults:** 200 mg initially followed by 100 mg every 12 hours or two or four 50 mg pellet-filled capsules may be given initially followed by one 50 mg capsule 4 times daily<br>**Pediatrics:** 4 mg/kg initially followed by 2 mg/kg every 12 hours; not to exceed the usual adult dose<br>Minocin pellet-filled capsules may be taken with or without food; swallow whole | 50 mg, 75 mg (generic only), 100 mg (generic only) pellet-filled capsules (Minocin 50 mg only)<br>50 mg, 75 mg, 100 mg capsules<br>50 mg, 75 mg, 100 mg tablets |
| minocycline ER (Solodyn, Minolira, Ximino) | **Age 12 years and older:** 1 mg/kg once daily for 12 weeks<br>Swallow whole, do not crush chew or split tablets/capsules; may be taken with or without food | 55 mg, 65 mg, 80 mg, 105 mg, 115 mg extended-release tablets (Solodyn)<br>45 mg, 90 mg, 135 mg extended-release tablets (Coremino ER)<br>105 mg and 135 mg extended-release tablets (Minolira)<br>45 mg, 90 mg, 135 mg extended-release capsules (Ximino) |

***Dosages (continued)***

| Drug | Usual Dosing | Availability |
|---|---|---|
| omadacycline (Nuzyra) | **CABP** (including IV initial with switch to oral):<br>*Loading dose:* 200 mg by IV infusion (using approved vial formulation) over 60 minutes on day 1; alternatively, a 100 mg IV infusion administered twice (each over 30 minutes on day 1) may be used, or 300 mg orally twice on day 1.<br>*Maintenance (day 2 and beyond):* 100 mg by IV infusion over 30 minutes once daily or 300 mg orally once daily; either formulation is given for the remainder of the treatment (total duration 7 to 14 days)<br><br>**ABSSSI** (including IV initial with switch to oral):<br>*Loading dose:* 200 mg by IV infusion (using approved vial formulation) over 60 minutes on day 1 only, or 100 mg IV over 30 minutes administered twice on day 1; alternatively, 450 mg orally on both days 1 and 2,<br>*Maintenance:* 100 mg IV infusion over 30 minutes once daily or 300 mg orally once daily; either formulation is given for the remainder of treatment (total duration 7 to 14 days) | 150 mg tablets |
| sarecycline (Seysara) | **Age 9 years and older:** dosing is weight based;<br>For those 33 to 54 kg, use the 60 mg tablet; for 55 to 84 kg, use the 100 mg tablet; for 85 to 136 kg, use the 150 mg tablet;<br>Take once daily with or without food; if no improvement following 12 weeks of use, treatment should be reassessed | 60 mg, 100 mg, 150 mg tablets |
| tetracycline | **Adults:** 250 to 500 mg every 6 hours or 500 to 1,000 mg every 12 hours; duration of therapy dependent on type and severity of infection<br>Acne rosacea: 250 to 1,500 mg per day<br>Inflammatory acne vulgaris: 125 to 250 mg every 6 hours then taper to 125 to 500 mg daily or every other day<br>**Pediatrics:** 25 to 50 mg/kg divided in 4 equal doses, not to exceed the usual adult dose | 250 mg, 500 mg capsules |

Administration of adequate amounts of fluid along with capsule and tablet forms of drugs in the tetracycline class is recommended to reduce the risk of esophageal irritation and ulceration.[119] Foods and some dairy products interfere with demeclocycline and tetracycline absorption. Oral forms of these agents should be given ≥ 1 hour before or 2 hours after meals. Patients should be instructed to fast for ≥ 4 hours prior to oral administration of omadacycline and then take the omadacycline dose with water. Following administration of omadacycline, no food or drink (other than water) should be consumed for 2 hours, and no dairy products, antacids, or multivitamins should be consumed for 4 hours. Doxycycline, minocycline, and sarecycline may be given with or without food. If gastric irritation occurs, it is recommended that doxycycline be given with food or milk. The usual dose and frequency of doxycycline products differs from other tetracyclines. Dosages in excess of the recommended amounts may result in increased adverse reactions.

# CLINICAL TRIALS

## Search Strategy

Articles were identified through searches performed on PubMed and review of information sent by manufacturers. Search strategy included the FDA-approved use of all drugs in this class. Randomized, controlled, comparative trials are considered the most relevant in this category. Studies included for analysis in the review were published in English, performed with human participants, and randomly allocated participants to comparison groups. In addition, studies must contain clearly stated, predetermined outcome measure(s) of known or probable clinical importance, use data analysis techniques consistent with the study question, and include follow-up (endpoint assessment) of at least 80% of participants entering the investigation. Despite some inherent bias found in all studies including those sponsored and/or funded by pharmaceutical manufacturers, the studies in this therapeutic class review were determined to have results or conclusions that do not suggest systematic error in their experimental study design. While the potential influence of manufacturer sponsorship and/or funding must be considered, the studies in this review have also been evaluated for validity and importance.

Much of the comparative literature within the class was published 20 to 30 years ago. Comparative literature for the tetracycline class was performed in the 1970s and 1980s. In the treatment of acne, minocycline was found to provide a more rapid response than tetracycline in 2 double-blind studies.[120,121] In another study, minocycline had superior antibacterial action and reduced the incidence of bacterial resistance in acne patients compared to tetracycline.[122] In an earlier double-blind study, minocycline 50 mg twice daily and tetracycline 250 mg twice daily had similar efficacy in the treatment of acne vulgaris.[123] When compared to other commonly used acne treatments, 1 study found minocycline to have the least improvement in lesions when compared to either erythromycin, oxytetracycline, or benzoyl peroxide alone.[124]

Doxycycline and tetracycline were compared in a small study of 24 patients with ocular rosacea.[125] Efficacy, based on subjective measures by the patients, was greater with tetracycline (p=0.041) at 6 weeks; however, after 3 months of treatment, symptoms scores were similar in both groups. Gastrointestinal adverse effects occurred more frequently with tetracycline (37.5%) than with doxycycline (12.5%). A more recent small study (n=15) published in 2014 showed markedly lessened symptom complaints in patients with ocular rosacea when they received low-dose once daily oral doxycycline.[126]

More recently, the tetracyclines have been compared in open-label trials to agents in other drug classes, such as azithromycin, tazarotene, oxytetracycline, benzoyl peroxide, and topical erythromycin.[127,128,129]

The newer extended-release dosage forms of doxycycline DR (Oracea) and minocycline ER (Solodyn, Minolira, Ximino) have only been compared to placebo in published literature.[130,131,132] Each agent showed significant improvement over placebo. The delayed-release form of doxycycline taken once daily proved to be effective in treating papulopustular rosacea in both males and females. Treatment success was achieved after 12 weeks of therapy in 73.2% of males (172 per 235) and 75.2% of females (444 per 591).[133] Similarly, sarecycline (Seysara) was compared to placebo in key clinical trials for approval.[134,135]

Omadacycline (Nuzyra) was compared against moxifloxacin for noninferiority in the Omadacycline for Pneumonia Treatment in the Community (OPTIC) trial.[136,137] Noninferiority was met; however, the omadacycline treated group had a higher all-cause mortality rate (2.1%) than the comparator group (1%). It also demonstrated noninferiority compared to linezolid in the treatment of ABSSSI in 2 clinical trials (OASIS-1 and OASIS-2).[138,139]

## META-ANALYSIS

A systematic review of the evidence of minocycline in the treatment of acne vulgaris identified randomized controlled trials (RCTs) of minocycline for acne vulgaris.[140] Articles were identified by searching the following databases: MEDLINE, EMBASE, Cochrane Skin Group's Trial Register, CENTRAL, LILACS, and a search of trial registers and reference lists. A total of 39 randomized controlled trials (6,013 participants) met the inclusion criteria and were included in the analysis which evaluated minocycline at any dose compared to either an active control or a placebo in participants with inflammatory acne vulgaris. Outcome measures in the trials included lesion counts, acne grades/severity scores, participant and doctor global assessments, adverse effects, and drop-out rates. The identified RCTs were generally small and of poor quality. Although minocycline was shown to be an effective treatment for acne vulgaris, there was no evidence demonstrating superiority to any other commonly used acne treatment. Minocycline is likely to be an effective treatment for moderate acne vulgaris, but no reliable trial evidence exists to justify its use as first-line therapy. Its efficacy and safety relative to other acne therapies could not be reliably determined due to the poor methodological quality of the trials and lack of consistent choice of outcome measures.

A Cochrane review of 14 studies regarding antibiotics used for the treatment of Chlamydia trachomatis infection in men and non-pregnant women demonstrated that use of azithromycin single dose resulted in a higher microbiological failure compared to doxycycline once or twice daily for 7 days in men (risk ratio [RR], 2.45; 95% confidence interval [CI], 1.36 to 4.41; 9 studies); however, no difference was found between the 2 agents with regard to clinical failure in men or in women.[141] Likewise, no difference in microbiologic or clinical failure was found when doxycycline was compared to ofloxacin in men or women (data on clinical failure only in women). While it is possible that azithromycin may be less effective in men than doxycycline, the results should be interpreted cautiously based on findings on clinical failures and the limited number of studies contributing to each outcome.

## SUMMARY

Tetracyclines are used in the treatment of a variety of infections in adults and children ≥8 years of age. Adverse effects common to the tetracyclines include gastrointestinal complaints and risk of esophageal ulceration.

Doxycycline is the antibiotic of choice among the tetracyclines for infections involving the upper respiratory tract, sexually transmitted diseases, and the urogenital tract (prostatitis, cervicitis, and urethritis). Doxycycline possesses unique characteristics, such as a broad spectrum of activity, a long serum half-life, greater tissue penetration, and excellent oral absorption, which contribute to its clinical superiority over tetracycline. The drug is not eliminated by the kidneys like tetracycline and is, therefore, the drug of choice when a tetracycline is indicated in patients with renal dysfunction and in hemodialysis patients. Doxycycline is also a preferred agent to prevent inhalational anthrax after confirmed or suspected aerosol exposure to *B. anthracis*.

Doxycycline DR (Oracea) is only indicated for the treatment of inflammatory lesions (papules and pustules) of rosacea in adults. It does not have a significant effect for generalized erythema of rosacea and has not been evaluated for treatment of erythematous, telangiectatic, or ocular components of rosacea, or in the prevention and treatment of infections. Minocycline ER (Solodyn, Minolira, Ximino) is only indicated for the treatment of inflammatory lesions of non-nodular moderate to severe acne vulgaris. Sarecycline (Seysara), approved in 2019, is also only approved for the treatment of inflammatory lesions of non-nodular moderate to severe acne vulgaris. Comparative literature for these agents is lacking.

Doxycycline hyclate 20 mg tablets are indicated as adjunctive therapy to scaling and root planing in reducing pocket depths and increasing periodontal attachment levels in patients with periodontal disease. Doxycycline hyclate 100 mg tablets (Lymepak) are only indicated in those with early Lyme disease as evidenced by erythema migrans due to *Borrelia burgdorferi* in those patients aged 8 years or older and weighing 45 kg or more.

Demeclocycline is used infrequently for the treatment of infections. The clinical use of demeclocycline is limited to treatment of syndrome of inappropriate antidiuretic hormone (SIADH). In a limited number of trials, demeclocycline has been effective in the treatment of water intoxication and inappropriate antidiuretic hormone secretion. When compared with tetracycline, demeclocycline is associated with a higher incidence of phototoxicity.

Omadacycline (Nuzyra) was approved for both community-acquired bacterial pneumonia (CABP) and acute bacterial skin and skin structure infections (ABSSSI) in 2018; it does not carry other indications. During its key noninferiority clinical trial for efficacy in CABP, the omadacycline-treated group had a higher all-cause mortality rate than those treated with moxifloxacin.

With the concern growing over resistance to agents in the tetracyclines class, it is becoming imperative that these drugs be used appropriately for conditions in which they are indicated.

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